



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.03.2020 Bulletin 2020/10

(51) Int Cl.:
H04B 10/112 (2013.01) **H02J 50/30** (2016.01)
H04B 10/114 (2013.01) **H04B 10/80** (2013.01)

(21) Application number: **19193252.4**

(22) Date of filing: **23.08.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(72) Inventors:
• **KIM, Kyunghwan**
08592 Seoul (KR)
• **YUK, Gyunghwan**
08592 Seoul (KR)
• **JUNG, Byungsang**
08592 Seoul (KR)

(30) Priority: **30.08.2018 KR 20180103040**

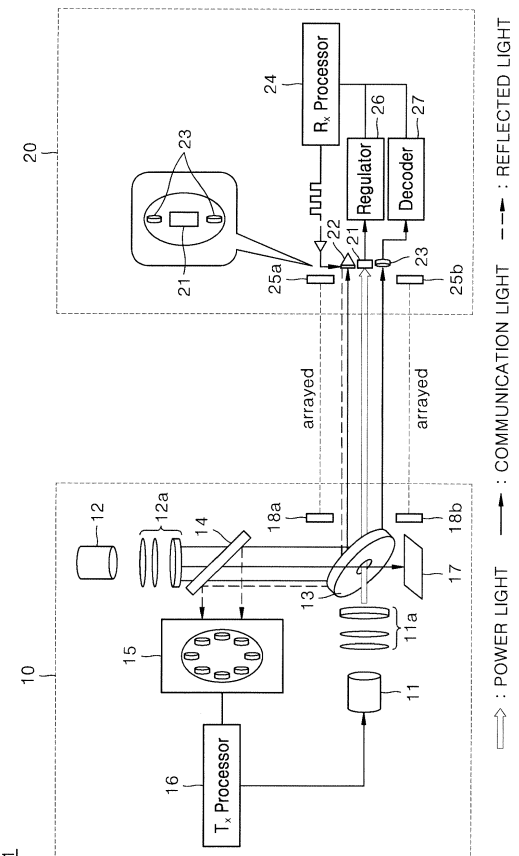
(74) Representative: **Vossius & Partner**
Patentanwälte Rechtsanwälte mbB
Siebertstrasse 3
81675 München (DE)

(71) Applicant: **LG ELECTRONICS INC.**
Yeongdeungpo-Gu
Seoul 07336 (KR)

(54) **OPTICAL WIRELESS POWER TRANSFER SYSTEM PERFORMING BIDIRECTIONAL COMMUNICATION**

(57) An optical wireless power transfer system that performs wireless bidirectional communication using light is provided. According to an embodiment of the present disclosure, the optical wireless power transfer system includes a transmission module that outputs power light and communication light including a first modulated signal and receives reflected light generated by reflecting the communication light, and process a second modulated signal included in the reflected light, and a reception module that processes the first modulated signal included in the communication light and outputs the reflected light by reflecting the communication light, and enables the second modulated signal to be included in the reflected light based on power generated based on the power light.

FIG. 2



Description

[0001] An optical wireless power transfer system performing wireless bidirectional communication using light is disclosed herein.

[0002] Recently, in a home appliance market, a main body that performs a main function and a wireless terminal capable of performing an additional function in conjunction with the main body may be provided together.

[0003] For example, in the cooktop market, which has recently greatly increased in size, the cooktop may include a main body that performs a function for heating food, and a detachable knob switch that may be removably attached to the main body and may perform additional functions for adjusting intensity of heating.

[0004] However, the wireless terminal provided as described above may require an additional battery to perform wireless communication with the main body, and a volume and a weight of the wireless terminal may be increased because the battery is mounted on the wireless terminal.

[0005] Further, as the battery is discharged over time, users may not only periodically replace the battery of the wireless terminal, but also a required function may not be performed through the wireless terminal when the battery is discharged in unexpected situations.

[0006] The present disclosure provides an optical wireless power transfer system that performs wireless bidirectional communication using light.

[0007] The present disclosure further provides an optical wireless power transfer system using light as a power source.

[0008] The present disclosure also provides an optical wireless power transfer system that transmits and receives a modulated signal through light.

[0009] The objects of the present disclosure are not limited to the above-mentioned objects, and other objects and advantages of the present disclosure which are not mentioned may be understood by the following description and more clearly understood by the embodiments of the present disclosure. It will also be readily apparent that the objects and the advantages of the present disclosure may be implemented by features defined in claims and a combination thereof.

[0010] According to the present disclosure, the optical wireless power transfer system may include a transmission module that outputs communication light or main light and receives a reflected light and processes a modulated signal included in the reflected light, and the reception module that processes the modulated signal included in the communication light or the main light and reflects the communication light or the main light and outputs the reflected light, to perform the wireless bidirectional communication using the light.

[0011] Further, according to the present disclosure, the optical wireless power transfer system may include the transmission module that outputs the power light or the main light and the reception module that receives the

power light or the main light to generate the power and enables the modulated signal to be included in the reflected light based on the generated power, to use the light as the power source.

[0012] Further, according to the present disclosure, the optical wireless power transfer system may include the transmission module that adjusts the intensity of the communication light or the main light and output the communication light or the main light and the reception module that identifies the modulated signal based on the intensity of the communication light or the main light, to transmit and receive the modulated signal through the light.

[0013] According to the present disclosure, the wireless bidirectional communication is performed using the light, thereby increasing a possible distance to perform communication between terminals.

[0014] Further, according to the present disclosure, additional battery may not be mounted on the wireless terminal using the light as the power source, thereby reducing the volume and the weight of the terminal.

[0015] Further, according to the present disclosure, the modulated signal may be transmitted and received through the light, thereby preventing electro magnetic interference (EMI) that occurs based on periphery electronic devices.

FIG. 1 shows an optical wireless power transfer system of the present disclosure.

FIG. 2 shows each component of an optical wireless power transfer system according to an embodiment of the present disclosure.

FIG. 3 shows a process of operating an optical wireless power transfer system of the present disclosure.

FIG. 4 shows a modulated signal transmitted and received between a transmission module and a reception module.

FIG. 5 shows each component of an optical wireless power transfer system according to another embodiment of the present disclosure.

FIG. 6 shows another example of a reception module shown in FIG. 5.

[0016] The above-mentioned objects, features, and advantages of the present disclosure will be described in detail with reference to the accompanying drawings. Accordingly, the skilled person in the art to which the present disclosure pertains may easily implement the technical idea of the present disclosure. In the description of the present disclosure, if it is determined that the detailed description of a well-known technology related to the present disclosure may unnecessarily obscure the gist of the present disclosure, the detailed description thereof is omitted. Preferred embodiments of the present disclosure are described in detail with reference to the accompanying drawings. In the drawings, same reference numerals are used to refer to same or similar components.

[0017] The present disclosure relates to an optical

wireless power transfer system capable of performing bidirectional communication wirelessly using light.

[0018] Hereinafter, the optical wireless power transfer system of the present disclosure will be described in detail with reference to FIGS. 1 to 6.

[0019] FIG. 1 shows an optical wireless power transfer system of the present disclosure.

[0020] FIG. 2 shows each component of an optical wireless power transfer system according to an embodiment of the present disclosure, and FIG. 3 shows a process of operating an optical wireless power transfer system of the present disclosure.

[0021] FIG. 4 shows a modulated signal transmitted and received between a transmission module and a reception module.

[0022] FIG. 5 shows each component of an optical wireless power transfer system according to another embodiment of the present disclosure. FIG. 6 shows another example of a reception module shown in FIG. 5.

[0023] Referring to FIG. 1, according to the present disclosure, an optical wireless power transfer system 1 may include a transmission module 10 and a reception module 20. The optical wireless power transfer system 1 shown in FIG. 1 is exemplary, and components of the optical wireless power transfer system 1 are not limited to the embodiment shown in FIG. 1, and some components of the optical wireless power transfer system 1 may be added, changed, or deleted as necessary.

[0024] As shown in FIG. 1, the transmission module 10 and the reception module 20 included in the optical wireless power transfer system 1 may be arrayed. In other words, each module may be arrayed at a preset position with respect to another module and may operate.

[0025] A method in which each module is arrayed and a method of determining, by the transmission module 10, a state in which modules are arrayed are described below.

[0026] The transmission module 10 may output power light and communication light including a first modulated signal, and may receive reflected light which is generated by reflecting the communication light, and may process a second modulated signal included in the reflected light.

[0027] To this end, the transmission module 10 may include a processor that processes a signal and two kinds of light sources that the output power light and the communication light, respectively.

[0028] Meanwhile, the reception module 20 may process the first modulated signal included in the communication light output by the transmission module 10, and may reflect the communication light, and may output the reflected light. At this time, the reception module 20 may enable the second modulated signal to be included in the reflected light based on power generated by the power light output by the transmission module 10.

[0029] To this end, the reception module 20 may include a processor that processes a signal, a reflector that reflects communication light, and an optical generator that generates power using the power light.

[0030] The optical wireless power transfer system 1 according to an embodiment of the present disclosure is described below in detail with reference to FIGS. 2 and 3.

[0031] Referring to FIG. 2, according to an embodiment of the present disclosure, the transmission module 10 may include a power light source 11, a communication light source 12, a mirror 13, a beam splitter 14, and a first light source, a transmitting processor 16, an optical absorber 17, and first magnetic bodies 18a and 18b.

[0032] Meanwhile, according to an embodiment of the present disclosure, the reception module 20 may include a photoelectric cell 21, a retro-reflector 22, a second photodiode 23, a receiving processor 24, and second magnetic bodies 25a, 25b, a regulator 26, and a decoder 27.

[0033] The transmission module 10 and the reception module 20 shown in FIG. 2 are exemplary, and components of the transmission module 10 and the reception module 20 are not limited to the embodiment shown in FIG. 2, and some components may be added, changed or deleted as necessary.

[0034] Hereinafter, a path of light output by the optical wireless power transfer system 1 according to an embodiment of the present disclosure is described below in detail with reference to FIG. 2.

[0035] A power light source 11 and a communication light source 12 of the transmission module 10 may output power light and communication light, respectively.

[0036] In the present disclosure, the power light and the communication light may perform functions, respectively. More specifically, the power light may be output by the transmission module 10 to provide the reception module 20 with the power, and communication light may be output by the transmission module 10 to provide the reception module 20 with a specific signal.

[0037] At least one of lens 11a, 12a may be further provided at an output end of the power light source 11 and an output end of the communication light source 12 to increase a light-transmission efficiency of each of the power light and the communication light, and the lenses 11a and 12a may be operated as a beam expander, a collimator, and the like.

[0038] The mirror 13 of the transmission module 10 may pass the power light and may reflect the communication light.

[0039] More specifically, the mirror 13 may pass the power light output by the power light source 11 without change. Further, the mirror 13 may reflect the communication light output by the communication light source 12 toward the reception module 20.

[0040] To this end, as shown in FIG. 2, the mirror 13 is a reflector in which a hole is provided to pass the power light, and may have a predetermined angle between the communication light 12 and the reception module 20.

[0041] Meanwhile, a portion of the communication light output by the communication light source 12 may pass through the hole provided in the mirror 13. The optical absorber 17 of the transmission module 10 may be placed on an extension line connecting the communica-

tion light source 12 and the hole to absorb the communication light that has passed through the hole provided in the mirror 13.

[0042] The transmitting processor Tx 16 of the transmission module 10 may control the communication light source 12 to enable the first modulated signal to be included in the communication light.

[0043] In the present disclosure, the modulated signal (the first modulated signal and the second modulated signal) may refer to all kinds of signals transmitted and received between the transmission module 10 and the reception module 20.

[0044] The transmitting processor 16 may control the first modulated signal to be included in the communication light through an on-off keying method, an intensity modulation (IM) method, and the like, and the method of generating the modulated signal is described below.

[0045] The photoelectric cell 21 of the reception module 20 may receive the power light to generate the power. The photoelectric cell 21 may be any element through which a current flows when light is received and may include a solar cell.

[0046] The photoelectric cell 21 may receive the power light output by the power light source 11 to generate the power based on the intensity of the light. As the power light output by the power light source 11 goes straight through the hole of the mirror 13 described above, the power light source 11 and the photoelectric cell 21 may be placed in the straight line.

[0047] As shown in FIG. 2, the photoelectric cell 21 may be connected to the regulator 26, and the regulator 26 may convert the power generated by the photoelectric cell 21 into a predetermined voltage and provides the receiving processor Rx Processor 24 with the predetermined voltage. Accordingly, the receiving processor 24 may be powered by the power generated by the photoelectric cell 21.

[0048] Meanwhile, the second photodiode 23 of the reception module 20 may convert the communication light into an electric signal. Further, the receiving processor 24 may identify the first modulated signal based on the electrical signal converted by the second photodiode 23 and may process the identified first modulated signal.

[0049] In the present disclosure, the photodiodes (a first photodiode 15 and a second photodiode 23) may be any semiconductor diodes that convert light energy into electrical signals. Such a photodiode may be a single element, or may have an array form in which a plurality of elements are regularly arranged.

[0050] The second photodiode 23 may convert the communication light output by the communication light source 12 into the electric signal based on the intensity of the light. The decoder 27 connected to the second photodiode 23 may convert the electrical signal output by the photodiode into a digital signal and may provide the receiving processor 24 with the converted digital signal.

[0051] The receiving processor 24 may identify the transmitted first modulated signal included in the communication light based on the digital signal provided by the second photodiode 23 and the decoder 27.

[0052] The receiving processor 24 may process the identified first modulated signal. More specifically, the receiving processor 24 may generate a control signal based on the first modulated signal or generate a response signal corresponding to the first modulated signal. Further, the receiving processor 24 may perform various kinds of operations to process a signal.

[0053] Meanwhile, the retro-reflector 22 of the reception module 20 may retro-reflect the communication light to output the reflected light.

[0054] More specifically, the retro-reflector 22 may output the reflected light by reflecting the incident communication light in a direction opposite to an incident direction. To this end, as shown in FIG. 2, the retro-reflector 22 may be placed in the straight line with respect to the incidence direction of the communication light.

[0055] At this time, the receiving processor 24 may control the retro-reflector 22 to enable the second modulated signal to be included in the reflected light based on the power generated by the photoelectric cell 21.

[0056] The receiving processor 24 may control the second modulated signal to be reflected on the reflected light through the on-off keying method and the method of generating the modulated signal is described below.

[0057] The mirror 13 of the above-described transmission module 10 may reflect the reflected light. More specifically, as shown in FIG. 2, the mirror 13 may reflect the reflected light output by the retro-reflector 22 toward the communication light source 12.

[0058] The beam splitter 14 of the transmission module 10 may reflect back the reflected light, which has been reflected by the mirror 13.

[0059] The beam splitter 14 may be provided between the mirror 13 and the communication light source 12 to pass a portion of the incident light and reflect other portions of the incident light. Accordingly, the communication light incident on the mirror 13 may be output by the communication light source 12 and passes through the beam splitter 14.

[0060] As shown in FIG. 2, the light is reflected by the mirror 13 and is incident toward the communication light source 12 and the beam splitter 14 may reflect again the above-mentioned light toward the first light diode 15.

[0061] The first photodiode 15 may convert the reflected light, which has been reflected back by the beam splitter 14 into an electrical signal based on the intensity of the light. The electrical signal converted as described above may be provided to the transmitting processor 16. Meanwhile, as described above, a decoder may be used to convert the electrical signal converted by the first photodiode 15 into the digital signal.

[0062] The transmitting processor 16 may identify the second modulated signal included in the reflected light based on the electrical signal provided through the first

photodiode 15, and may perform various kinds of operations to process the signal based on the identified second modulated signal.

[0063] Hereinafter, a method of communicating, by the transmission module and the reception module 20 and a method of transmitting the power are described below in detail with reference to FIGS. 2 and 3.

[0064] As described above, the transmission module 10 and the reception module 20 may perform the communication and the power transmission using the light that goes straight. Accordingly, each module may be required to be arrayed at a preset position with respect to another module to be operated.

[0065] Referring to FIG. 3, in order to determine the above-described array state of modules, the transmission module 10 may determine whether the reception module 20 is arrayed at a preset position in a ping mode (S10).

[0066] More specifically, the transmission module 10 may output the communication light having a reference intensity and may determine whether the intensity of the received reflected light is greater than or equal to the reference intensity.

[0067] The transmission module 10 may output communication light having the reference intensity, in a form of a continuous wave in the ping mode (S10).

[0068] In this case, when the transmission module 10 and the reception module 20 are not arrayed, the communication light may not be reflected by the reception module 20 and thus the reflected light may not be received at the transmission module 10. To the contrary, when the transmission module 10 and the reception module 20 are arrayed, the communication light may be reflected by the reception module 20 and thus the reflected light may be received at the transmission module 10.

[0069] The transmission module 10 may determine that, when the intensity of the received reflected light is equal to or greater than a reference intensity, the reception module 20 is arrayed at the preset position, and may determine that, when the intensity of the received reflected light is less than the reference intensity, the reception module 20 is not arrayed at the preset position.

[0070] For example, the transmission module 10 may determine whether the reception module 20 is arrayed based on comparison of the magnitude of voltage generated based on the reflected light with the reference voltage (S11).

[0071] More specifically, when the optical wireless power transfer system 1 is provided as shown in FIG. 2, the reflected light output by a retro-reflector 22 may be received at the first photodiode 15. The reflected light received at the first photodiode 15 may be converted into a voltage V_i having a predetermined magnitude based on the intensity thereof, and the transmitting processor 16 may compare a total of voltages ΣV_i converted by the first photodiode 15 with a reference voltage V_{ref} .

[0072] The transmitting processor 16 may determine that, when the total of the voltages ΣV_i converted by the

first diode 15 is equal to or greater than the reference voltage V_{ref} , the reception module 20 is arrayed at the preset position. To the contrary, the transmitting processor 16 may determine that, when the total of voltages ΣV_i converted by the first light diode 15 is less than the reference voltage V_{ref} , the reception module 20 is not arrayed at the preset position.

[0073] When it is determined that the reception module 20 is arrayed at the preset position, the transmission module 10 may output the above-mentioned power light and may enable the first modulated signal to be included in the communication light.

[0074] In other words, in the ping mode S10, the transmission module 10 outputs only communication light having a reference intensity in a form of continuous wave without outputting the power light, and may output the power light and may output the communication light including the first modulated signal, when it is determined that the reception module 20 is arrayed at the preset position.

[0075] Meanwhile, the transmission module 10 and the reception module 20 may include first and second magnetic bodies 18a, 18b, 25a, and 25b, respectively, to maintain the above-mentioned array state. A plurality of first magnetic bodies 18a and 18b and a plurality of second magnetic bodies 25a and 25b may be provided, respectively, and an attraction may be generated between the first magnetic bodies 18a and 18b and the second magnetic bodies 25a and 25b.

[0076] For example, as shown in FIG. 2, the transmission module 10 may include a plurality of first magnetic bodies 18a and 18b, and the reception module 20 may also include a plurality of second magnetic bodies 25a and 25b. In this case, surfaces facing each other, of the first magnetic bodies 18a and 18b and the second magnetic bodies 25a and 25b, may have different polarities, and accordingly, the attraction may occur between the first magnetic bodies 18a and 18b and the second magnetic bodies 25a.

[0077] The attraction may enable the transmission module 10 and the reception module 20 to be fixed within a predetermined distance. For example, when a light transmitting material such as plastic or glass are provided between the transmission module 10 and the reception module 20, positions of the transmission module 10 and the reception module 20 may be fixed at both ends of the light transmitting material, respectively, based on the attraction generated between the first magnetic bodies 18a and 18b and the second magnetic bodies 25a and 25b.

[0078] Accordingly, after the transmission module 10 and the reception module 20 are arrayed once, the array state may be maintained by the above-described magnetic bodies 18a, 18b, 25a, and 25b unless an external force having a predetermined magnitude or more is applied.

[0079] Referring back to FIG. 3, when each module is arrayed, the optical wireless power transfer system 1 may operate in a negotiation mode (S20).

[0080] In the negotiation mode S20, the transmission module 10 may gradually increase, until when a completion message is received from the reception module 20, the magnitude of the power light and may output the power light.

[0081] Meanwhile, in the negotiation mode S20, the reception module 20 may generate a second modulated signal including the completion message when the power generated by the power light is greater than or equal to the required power P_{req} .

[0082] Referring to FIG. 2, the photoelectric cell 21 may receive the power light a magnitude of which is gradually increased and output and may generate the power P_{out} . The receiving processor 24 may compare the magnitude of the generated power P_{out} with the magnitude of the required power P_{req} (S21).

[0083] As a result of comparison, when the magnitude of the generated power P_{out} is equal to or greater than the magnitude of the required power P_{req} , the receiving processor 24 may generate the second modulated signal including the completion message. Subsequently, the receiving processor 24 may control the retro-reflector 22 to enable the second modulated signal including the completion message, to be included in the reflected light.

[0084] The transmitting processor 16 may process the second modulated signal included in the reflected light to identify the completion message, and when the completion message is identified, the transmitting processor 16 may maintain a predetermined magnitude of the power light.

[0085] To the contrary, when the magnitude of the generated power P_{out} is less than the magnitude of the required power P_{req} , the receiving processor 24 may generate the second modulated signal including the request message. Subsequently, the receiving processor 24 may control the retro-reflector 22 to enable the second modulated signal to be included in the reflected light, and the second modulated signal includes the request message. The output operation of the request message may be performed during a preset period of time.

[0086] The transmitting processor 16 may gradually increase the magnitude of the power light every time the request message is received.

[0087] More specifically, the transmitting processor 16 may process the second modulated signal included in the reflected light to identify the request message and gradually increase the magnitude of the power light every time the request message is identified.

[0088] Referring back to FIG. 3, when the power generated by the reception module 20 is greater than or equal to the required power and the negotiation mode S20 is completed, the optical wireless power transfer system 1 may perform in a power transfer mode (S30).

[0089] In the power transfer mode (S30), operation of transferring power may be performed through the power light output by the transmission module 10 and operation of transmitting and receiving a signal may be performed through the communication light and the reflected light

output by the transmission module 10 and the reception module 20.

[0090] As the operation of transmitting the power and the operation of transmitting and receiving the signal have been described with reference to FIG. 2, a detailed description thereof is omitted.

[0091] Meanwhile, in the power transmission mode S30, when the power is generated based on the power light, the reception module 20 may generate a second modulated signal including a message of the received power M_r during a reference period of time.

[0092] Further, when the message of the received power M_r is not received for a preset period of time, the transmission module 10 may block the output of power light (Laser Off) (S40).

[0093] Referring to FIG. 2, when the power is generated by the power light received at the photoelectric cell 21 in the power transfer mode S30, the receiving processor 24 may generate the second modulated signal including the message of the received power M_r during the reference period of time T_m .

[0094] Subsequently, the receiving processor 24 may control the retro-reflector 22 to enable the second modulated signal to be included in the reflected light and the second modulated signal includes the message of the receiver power M_r . As the message of the received power M_r is generated during the reference period of time T_m , the second modulated signal including the message of the received power M_r may also be output through the reflected light during the reference period of time T_m (S31).

[0095] The transmitting processor 16 may identify the message of the received power M_r by processing the second modulated signal included in the reflected light, and may continuously output the power light and the communication light when the message of the received power M_r is identified.

[0096] When the transmission module 10 and the reception module 20 are arrayed, the transmission module 10 may receive the message of the received power M_r during a predetermined period of time T_r for which the message of the received power is received. As the second modulated signal including the message of the received power M_r is output during the reference period of time T_m , the message of the received power M_r may be received at the transmitting module 10 during the same period of time T_r for which the message of the received power is received.

[0097] At this time, when a change occurs in the position of the transmission module 10 or the reception module 20 and the above-described array state may not be maintained, the power light may not be received at the photoelectric cell 21 of the reception module 20, and accordingly, the receiving processor 24 may not generate the second modulated signal including the message of the received power M_r . Further, when the array state is not maintained, even if the second modulated signal is generated, the reflected light including the second mod-

ulated signal may not be received at the transmission module 10.

[0098] The transmission module 10 may compare the period of time T_r for which the message of the received power M_r is received with a preset time T_{ref} (S32), and as a result of comparison, the transmission module 10 may block, when the period of time T_r for which the message of the received power M_r is received exceeds a preset time T_{ref} , the output of the power light.

[0099] The preset time T_{ref} may be set longer than the aforementioned reference period of time T_m .

[0100] Further, when the message of the received power M_r is not received within a preset period of time, the transmission module 10 may operate in the ping mode S10 described above to output communication light having the reference intensity. As the operation process after the ping mode S10 has been described above, a detailed description thereof is omitted.

[0101] As described above, when the transmission module 10 and the reception module 20 do not maintain the array state, operation of determining the array state thereof is automatically performed through operation of blocking the output (S40) and in the ping mode (S10), thereby saving the energy and improving reliability in communication.

[0102] The modulated signals output by the transmission module 10 and the reception module 20 are described below with reference to FIG. 4.

[0103] The transmission module 10 may adjust the intensity of the communication light and output the communication light, and the reception module 20 may identify the first modulated signal based on the intensity of the communication light.

[0104] More specifically, the transmitting processor 16 may control the first modulated signal to be included in the communication light through the on-off keying method, the intensity modulation (IM) method, and the like.

[0105] However, as described above, the reception module 20 outputs the reflected light including the second modulated signal by reflecting the communication light. To this end, the communication light may have a continuous output. Accordingly, the first modulated signal is preferably included in the communication light through the IM method.

[0106] Referring to FIG. 4, the transmitting processor 16 may adjust the intensity of communication light through the IM method to transmit a first modulated signal including bits of '101001'. More specifically, the communication light may have different intensities corresponding to bits 1 and 0, respectively, and the transmitting processor 16 adjusts the intensity of the communication light to include the first modulated signal, which is a combination of bits 1 and 0, in the communication light.

[0107] As described above, the second photodiode 23 of the reception module 20 may generate an electrical signal based on the intensity of the communication light, and the receiving processor 24 may identify the first modulated signal included in the communication light as

'101001' based on the magnitude of the electrical signal.

[0108] Meanwhile, the reception module 20 may reflect the communication light through the on-off keying method and may output the reflected light including the second modulated signal.

[0109] Referring back to FIG. 4, the receiving processor 24 may control a reflection operation of the retro-reflector 22 through the on-off keying method to transmit a second modulated signal including bits of '101011'.

[0110] More specifically, the receiving processor 24 may control the retro-reflector 22 to perform the reflection operation during the period of time corresponding to bit 1, and may control the retro-reflector 22 not to perform the reflection operation during the period of time corresponding to bit 0.

[0111] Accordingly, as shown in FIG. 4, the reflected light may be output only during the period of time corresponding to bit 1. As the reflected light is output by reflecting the communication light, the intensity of the reflected light output may be proportional to the intensity of the communication light.

[0112] As described above, the first photodiode 15 of the transmission module 10 may generate the electrical signal based on the intensity of the reflected light, and the transmitting processor 16 may identify a second modulation included in the reflected light, as '101011', based on the magnitude of the electrical signal.

[0113] An optical wireless power transfer system 1' according to another embodiment of the present disclosure is described below in detail with reference to FIGS. 5 and 6.

[0114] According to another embodiment of the present disclosure, as shown in FIG. 1, the optical wireless power transfer system 1' may include a transmission module 10' and a reception module 20' arrayed with respect to the transmission module 10'.

[0115] The transmission module 10' may output the main light including the first modulated signal and may receive the reflected light generated by reflecting a portion of the main light, and process the second modulated signal included in the reflected light.

[0116] To this end, the transmission module 10' may include a processor that processes a signal and a single light source that outputs the main light.

[0117] Meanwhile, the reception module 20' may process the first modulated signal included in the main light and may reflect a portion of the main light to output the reflected light, and may enable the second modulated signal to be included in the reflected light based on the power generated due to the main light.

[0118] To this end, the reception module 20' may include a processor that processes a signal, a reflector that reflects a portion of the main light, and an optical generator that generates power using the main light.

[0119] Referring to FIGS. 5 and 6, according to another embodiment of the present disclosure, a transmission module 10' may include a main light source 11', a beam splitter 12', a first photodiode 13', and a transmitting proc-

essor 14', an optical absorber 16', and first magnetic bodies 15a' and 15b'.

[0120] Meanwhile, according to another embodiment of the present disclosure, the reception module 20' may include a photoelectric cell 21', a retro-reflector 22', a second photodiode 23', a receiving processor 24', and the second magnetic bodies 25a' and 25b', a regulator 26', and a decoder 27'.

[0121] The transmission module 10' and the reception module 20' shown in FIGS. 5 and 6 are exemplary, and components of the transmission module 10' and the reception module 20' are not limited to the embodiment shown in FIG. 2, and some components of the transmission module 10' and the reception module 20' may be added, changed or deleted as necessary.

[0122] Basically, each component shown in FIGS. 5 and 6 may be the same as described with reference to FIG. 2.

[0123] More specifically, the beam splitter 12', the first photodiode 13', the transmitting processor 14', and the first magnetic bodies 15a' and 15b' and the optical absorber 16' included in the transmission module 10' shown in FIGS. 5 and 6 may have the same functions as the beam splitter 14, the first photodiode 15, the transmitting processor 16, the first magnetic bodies 18a and 18b, and the optical absorber shown in FIG. 2, respectively.

[0124] That is, as shown in FIGS. 5 and 6, the transmission module 10' has a less number of light sources than the transmission module 10 shown in FIG. 2. All other configurations, except for the omitted configurations, may be the same as configurations as shown in FIG. 2 due to the reduced number of light sources.

[0125] Meanwhile, each component included in the reception module 20 shown in FIGS. 5 and 6 may be the same as described with reference to FIG. 2. In other words, the photoelectric cell 21', the retro-reflector 22', the second photodiode 23', the receiving processor 24', and the second magnetic bodies 25a' and 25b', the regulator 26' and the decoder 27' included in the reception module 20' shown in FIGS. 5 and 6 may have the same functions as the photoelectric cell 21, the retro-reflector 22, the second photodiode 23 and the receiving processor 24, the second magnetic bodies 25a and 25b, the regulator 26 and the decoder 27 shown in FIG. 2, respectively.

[0126] Accordingly, light and paths of light different from those described in FIG. 2 are described below with reference to FIGS. 5 and 6.

[0127] A main light source 11' of the transmission module 10' may output the main light.

[0128] In the present disclosure, the main light may include both the power light and the communication light described with reference to FIG. 2 with respect to the function thereof. More specifically, the main light may enable the power to be provided to the reception module 20' and may be output to provide the reception module 20' with a specific signal.

[0129] For example, as shown in FIG. 5, the main light

may include the power light output from a center portion thereof and communication light output from a peripheral portion thereof.

[0130] The beam splitter 12' of the transmission module 10' may pass the main light.

[0131] More specifically, the beam splitter 12' may be provided between the main light source 11' and the reception module 20' to pass a portion of incident light and reflect other portions of the incident light. Accordingly, the main light incident on the reception module 20' may be output by the main light source 11' and may pass through the beam splitter 12.

[0132] The transmitting processor 14' of the transmission module 10' may control the main light source 11' to enable the first modulated signal to be included in the main light. More specifically, the transmitting processor 14' may adjust the intensity of the main light and may output the main light having the adjusted intensity to control the first modulated signal to be included in the main light.

[0133] As a method of including the first modulated signal in the main light by adjusting the intensity of the light is the same as the method of including the first modulated signal in the communication light described with reference to FIG. 4, a detailed description thereof is omitted.

[0134] The photoelectric cell 21' of the reception module 20' may receive the main light to generate the power. To this end, the main light source 11' of the transmission module 10' and the photoelectric cell 21' of the reception module 20' may be placed in a straight line.

[0135] The regulator 26' may convert the power generated by the photoelectric cell 21' into a predetermined voltage and may provide the receiving processor 24' with the predetermined voltage, and accordingly, the receiving processor 24' may receive the power based on the power generated by the photoelectric cell 21'.

[0136] Meanwhile, the second photodiode 23' of the reception module 20' may convert a portion of the main light into an electrical signal. More specifically, the second photodiode 23' may receive a portion of the main light according to position thereof and may convert the portion of the main light into the electrical signal. The decoder 27' may convert the converted electrical signal into a digital signal and provide the receiving processor 24' with the converted digital signal.

[0137] The receiving processor 24' may identify the first modulated signal based on the electrical signal converted by the second photodiode 23' and may process the identified first modulated signal. More specifically, the receiving processor 24' may identify the first modulated signal based on the intensity of the main light.

[0138] As the method of identifying the first modulated signal based on intensity of the light has been described with reference to FIG. 4, a detailed description thereof is omitted.

[0139] Meanwhile, the retro-reflector 22' of the reception module 20' may retro-reflect a portion of the main light to output the reflected light. More specifically, the

retro-reflector 22' may retro-reflect a portion of the main light according to the position thereof, and to this end, the retro-reflector 22' may be placed in the straight line with respect to the incident direction of the main light.

[0140] At this time, the receiving processor 24' may control the retro-reflector 22' to enable the second modulated signal to be included in the reflected light based on the power generated by the photocell 21'. As the method of including the second modulated signal in the reflected light is the same as the method described with reference to FIG. 4, a detailed description thereof is omitted.

[0141] The beam splitter 12' of the above-described transmission module 10' may reflect the reflected light. More specifically, as shown in FIGS. 5 and 6, the beam splitter 12' may reflect a portion of the reflected light output by the retro-reflector 22' toward the first photodiode 13.

[0142] The first photodiode 13' may convert the reflected light reflected by the beam splitter 12' into the electrical signal based on the intensity of the light, and the converted electrical signal may be provided to the transmitting processor 14'.

[0143] The transmitting processor 14' may identify the second modulated signal included in the reflected light based on the electrical signal provided through the first photodiode 13' and may perform operation of processing various kinds of signals based on the identified second modulated signal.

[0144] Meanwhile, as shown in FIG. 5, the photoelectric cell 21', the retro-reflector 22', and the second photodiode 23' may be provided at any position such that the photoelectric cell 21', the retro-reflector 22', and the second photodiode 23' may receive the main light. More specifically, the retro-reflector 22' and the second photodiode 23' may be arbitrarily arranged in the region where the main light is received.

[0145] For example, referring to FIG. 6, the retro-reflector 22' may be provided at a center of the region where the main light is received, and a plurality of cells included in the photoelectric cell 21' and the second photodiode 23' may have a circular shape or rectangular matrix shape with respect to the retro-reflector 22'.

[0146] Further, the retro-reflector 22', the second photodiode 23', the plurality of cells included in the photoelectric cell 21' may have any arrangement within the circular shape or the rectangular matrix shape.

[0147] As described above, according to the present disclosure, wireless bidirectional communication is performed using the light, thereby increasing the possible distance to perform the communication between terminals. Further, according to the present disclosure, additional battery may not be mounted on the wireless terminal using the light as the power source, thereby reducing the volume and the weight of the terminal.

[0148] Further, according to the present disclosure, the modulated signal may be transmitted and received through the light, thereby preventing the electro magnetic

interference (EMI) generated by peripheral electronic devices.

5 Claims

1. An optical wireless power transfer system, comprising:

10 a transmission module (10) configured to output power light and communication light comprising a first modulated signal, and receive reflected light, the reflected light generated by reflecting the communication light, and process a second modulated signal comprised in the reflected light; and
15 a reception module (20) configured to process the first modulated signal comprised in the communication light, and reflect the communication light to output the reflected light, and enable the second modulated signal to be comprised in the reflected light based on power generated by the power light.

25 2. The optical wireless power transfer system of claim 1, wherein the transmission module (10) comprises:

30 a power light source (11) configured to output the power light;
a communication light source (12) configured to output the communication light;
a mirror (13) configured to pass the power light and reflect the communication light and the reflected light,
35 a beam splitter (14) configured to reflect the reflected light again, which was reflected by the mirror (13),
a first photodiode (15) configured to convert the reflected light, which was reflected again, into an electrical signal;
40 a transmitting processor (16) configured to control the communication light source (12) to enable the first modulated signal to be comprised in the communication light, identify the second modulated signal based on the converted electrical signal, and process the identified second modulated signal.

50 3. The optical wireless power transfer system of claim 1 or 2, wherein the reception module (20) comprises:

55 a photoelectric cell (21) configured to receive the power light and generate the power;
a retro-reflector (22) configured to retro-reflect the communication light and output the reflected light;
a second photodiode (23) configured to convert the communication light into an electrical signal;

- a receiving processor (24) configured to control the retro-reflector (22) to enable the second modulated signal to be comprised in the reflected light based on the power generated by the photoelectric cell (21) and identify the first modulated signal based on the converted electrical signal, and process the identified first modulated signal.
4. The optical wireless power transfer system of claim 1, 2 or 3, wherein the transmission module (10) is configured to output the communication light having a reference intensity, and output, when an intensity of the received reflected light is greater than or equal to a reference intensity, the power light and enable the first modulated signal to be comprised in the communication light.
 5. The optical wireless power transfer system of any one of claims 1 to 4, wherein the transmission module (10) is configured to gradually increase and outputs, until a completion message is received from the reception module (20), a magnitude of the power light, and wherein the reception module (20) generates, when the power generated by the power light is greater than or equal to a required power, the second modulated signal comprising the completion message.
 6. The optical wireless power transfer system of claim 5, wherein the reception module (20) generates, when the power generated by the power light is less than the required power, the second modulated signal comprising a request message, and wherein the transmission module (10) is configured to gradually increase, when the request message is received, the magnitude of the power light and output the power light.
 7. The optical wireless power transfer system of any one of claims 1 to 6, wherein the reception module (20) is configured to generate, when the power is generated based on the power light, the second modulated signal comprising a message of the received power during a reference period of time, and wherein the transmission module (10) is configured to prevent, when the message of the received power is not received during a preset period of time, the power light from being output.
 8. The optical wireless power transfer system of claim 7, wherein the transmission module (10) is configured to output, when the message of the received power is not received during a preset period of time, the communication light having a reference intensity.
 9. The optical wireless power transfer system of any one of claims 1 to 8, wherein the transmission module (10) is configured to adjust an intensity of the communication light and output the communication light, and wherein the reception module (20) is configured to identify the first modulated signal based on the intensity of the communication light.
 10. The optical wireless power transfer system of any one of claims 1 to 9, wherein the reception module (20) is configured to reflect the communication light through an on-off keying method and output the reflected light comprised in the second modulated signal.
 11. An optical wireless power transfer system, comprising:
 - a transmission module (10') configured to output a main light comprising a first modulated signal and receive a reflected light generated by reflecting a portion of the main light, and process a second modulated signal comprised in the reflected light; and
 - a reception module (20') configured to process the first modulated signal comprised in the main light and reflect a portion of the main light and output the reflected light, and enable the second modulated signal to be comprised in the reflected light based on a power generated based on the main light.
 12. The optical wireless power transfer system of claim 11, wherein the transmission module (10') comprises:
 - a main light source (11') configured to output the main light;
 - a beam splitter (12') configured to pass the main light and reflects the reflected light;
 - a first photodiode (13') configured to convert the reflected light into an electrical signal;
 - a transmitting processor (14') configured to control the main light source (11') to enable the first modulated signal to be comprised in the main light, identify the second modulated signal based on the converted electrical signal, and process the identified second modulated signal.
 13. The optical wireless power transfer system of claim 11 or 12, wherein the reception module (20') comprises:
 - a photoelectric cell (21') configured to receive the main light to generate the electric power;
 - a retro-reflector (22') that retro-reflects a portion of the main light to output the reflected light;

a second photodiode (23') configured to convert a portion of the main light into an electrical signal; a receiving processor (24') configured to control the retro-reflector (22') to enable the second modulated signal to be comprised in the reflected light based on the power generated by the photoelectric cell (21') and identify the first modulated signal based on the converted electrical signal, and process the identified first modulated signal.

14. The optical wireless power transfer system of claim 11, 12 or 13, wherein the transmission module (10') is configured to adjust an intensity of the main light and output the main light, and wherein the reception module (20') is configured to identify the first modulated signal based on the intensity of the main light.
15. The optical wireless power transfer system of claim 13, wherein the retro-reflector (22'), the photoelectric cell (21'), and the second photodiode (23') have a matrix form in a region in which the main light is received.

30

35

40

45

50

55

FIG. 1

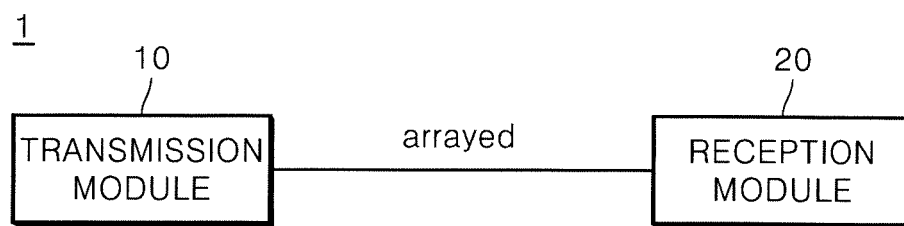


FIG. 2

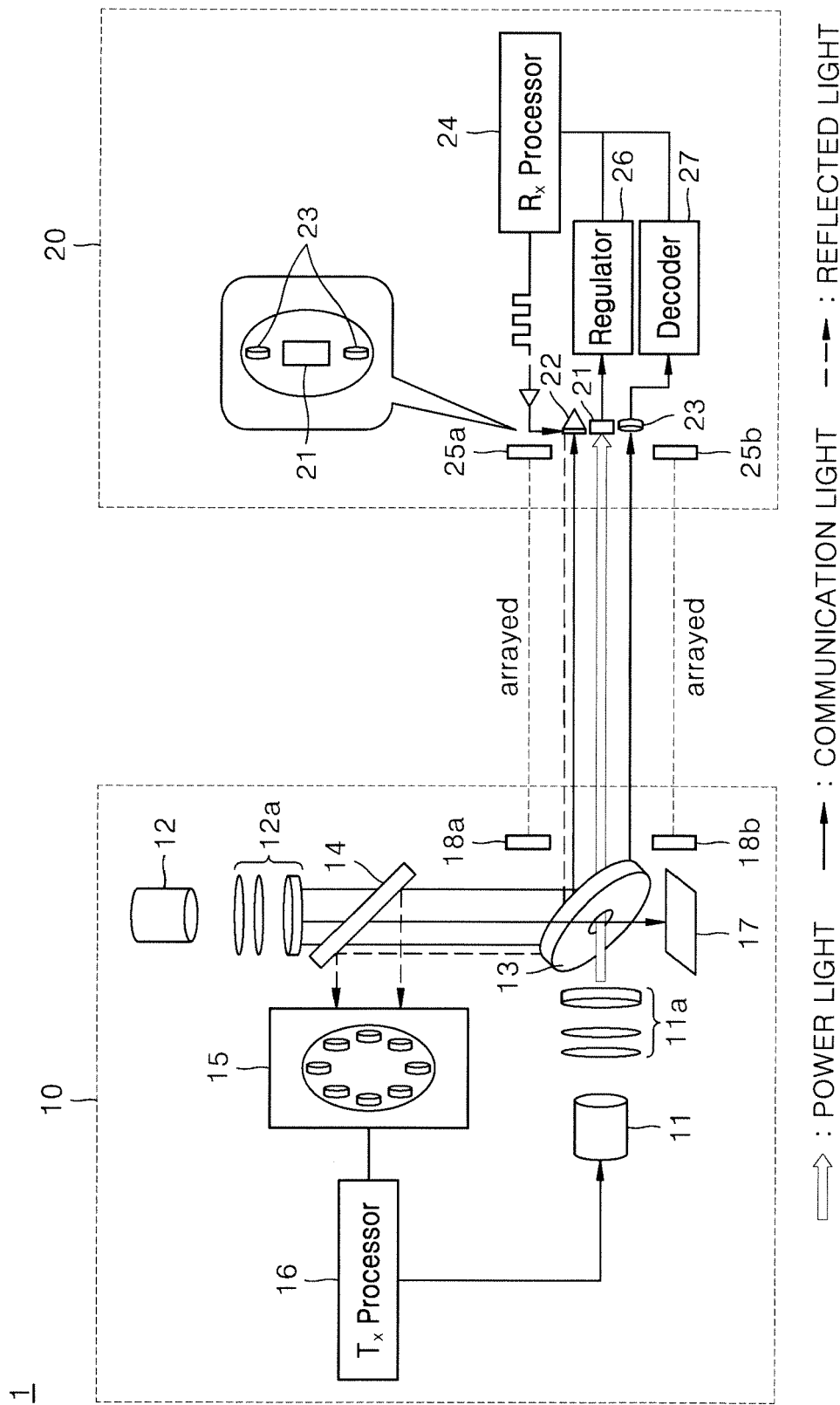


FIG. 3

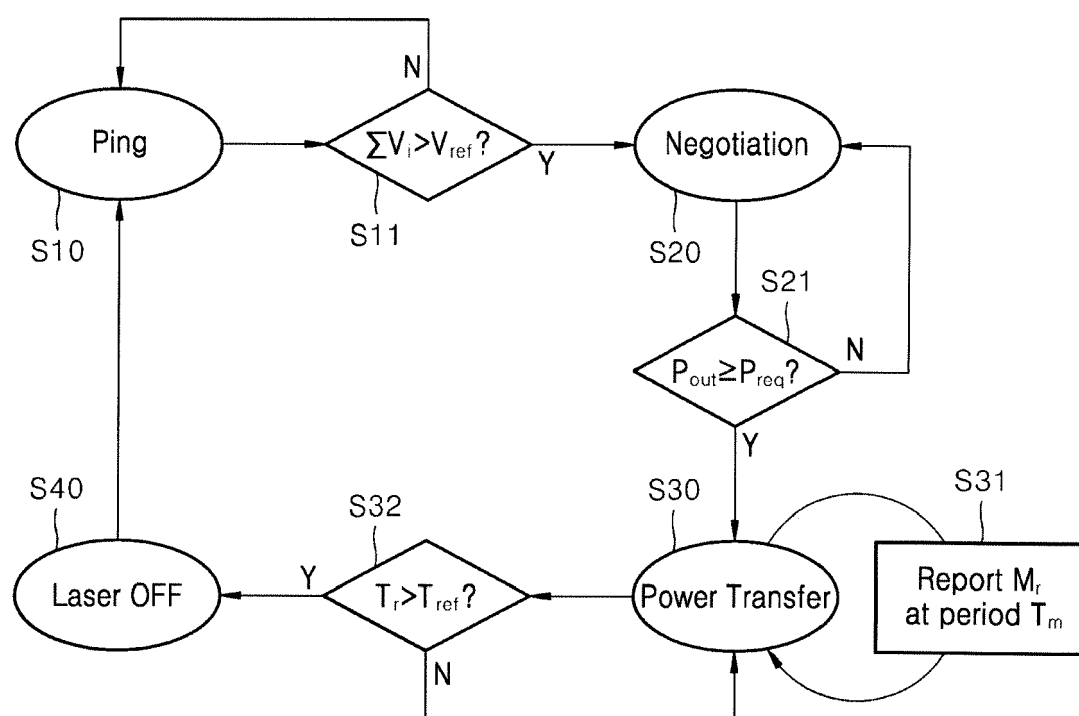


FIG. 4

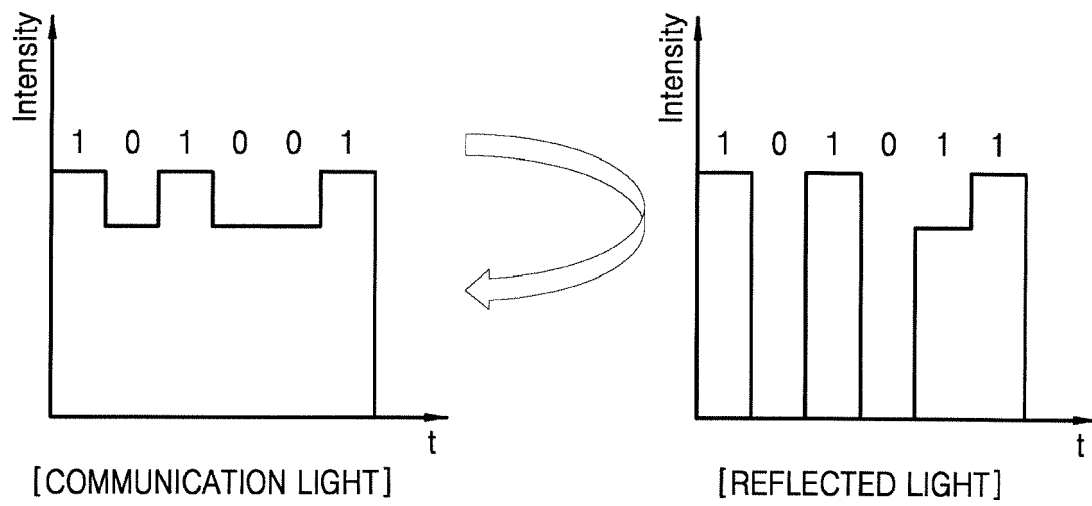


FIG. 5

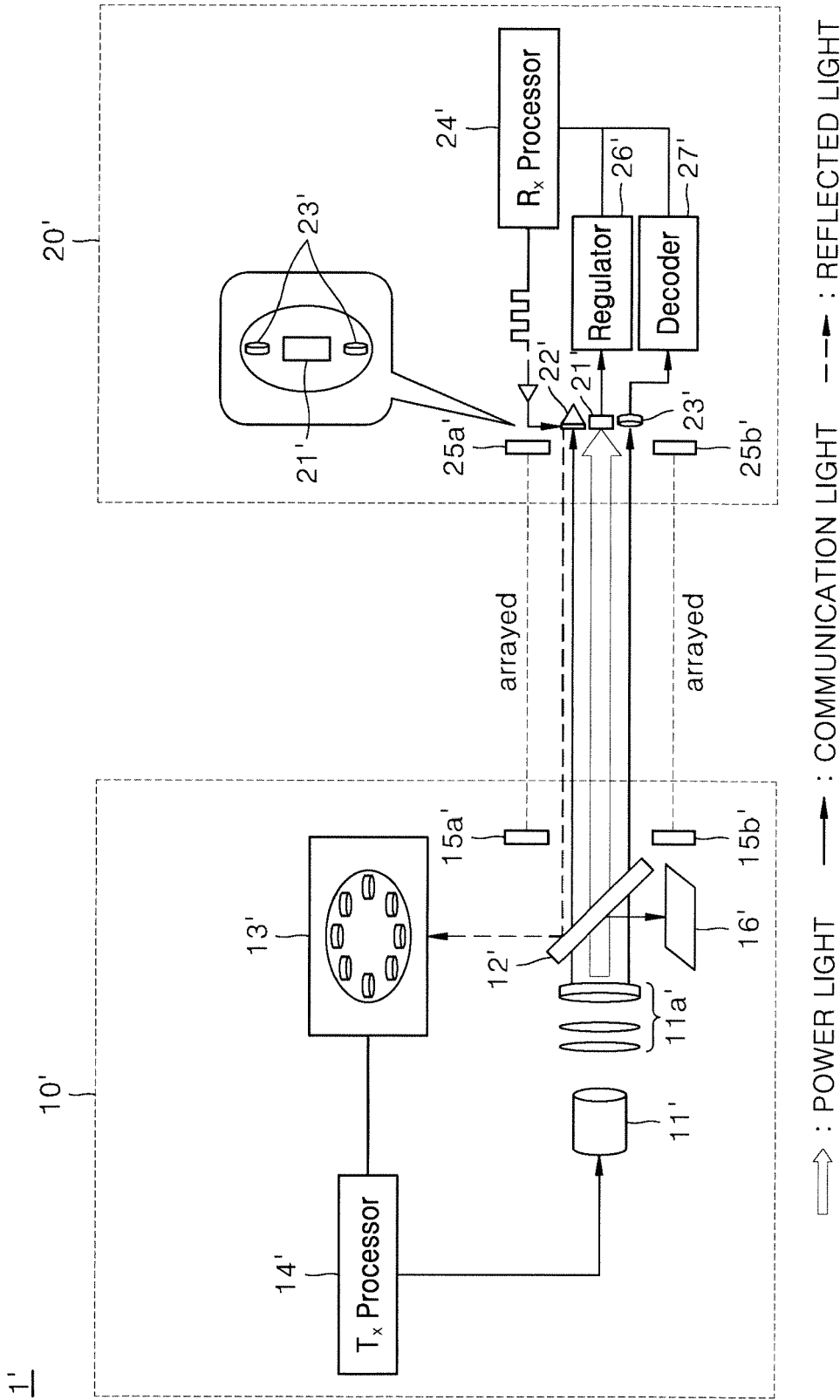
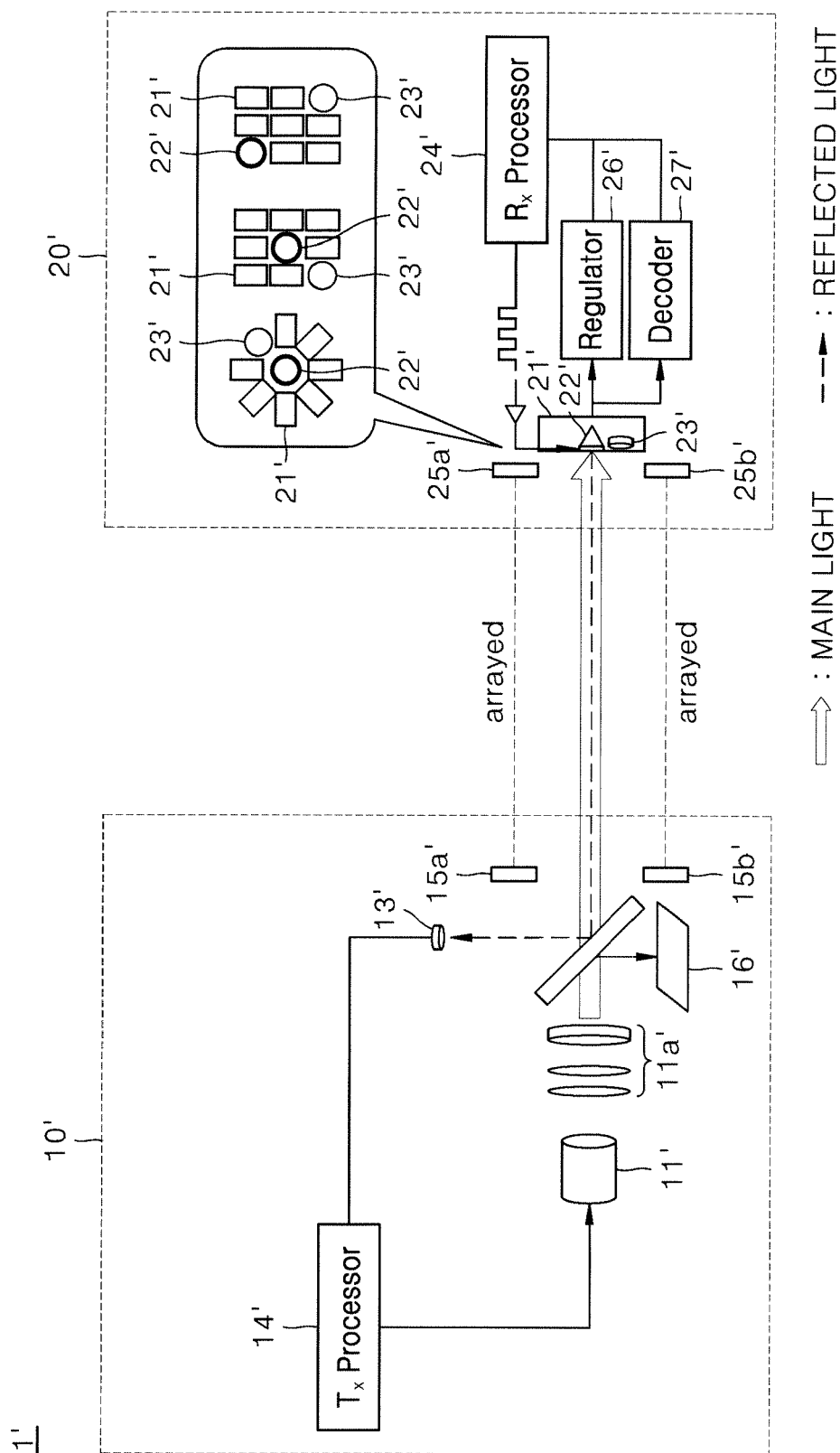


FIG. 6





EUROPEAN SEARCH REPORT

 Application Number
 EP 19 19 3252

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 3 076 201 A1 (ALCATEL LUCENT [FR]) 5 October 2016 (2016-10-05)	1,2,4-6, 14	INV. H04B10/112
Y	* column 9, paragraph 44 - pages 1-6,9,11,	7-12	H02J50/30
A	column 12, paragraph 70; figures 1-6,9,11 *	3,13,15	H04B10/114 H04B10/80
Y	----- WO 2018/135774 A1 (LG ELECTRONICS INC [KR]) 26 July 2018 (2018-07-26) * claims 7-12; figures 3-11 *	7-12	
X,P	----- DE 10 2017 220588 A1 (LUFTHANSA TECHNIK AG [DE]) 23 May 2019 (2019-05-23) * paragraph [0026] - paragraph [0031]; figure 2 *	1,11	

			TECHNICAL FIELDS SEARCHED (IPC)
			H04B H02J
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 9 January 2020	Examiner Koch, Bernhard
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	

 1
 EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 19 19 3252

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-01-2020

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3076201 A1	05-10-2016	NONE	
WO 2018135774 A1	26-07-2018	KR 20180085923 A	30-07-2018
		US 2019334389 A1	31-10-2019
		WO 2018135774 A1	26-07-2018
DE 102017220588 A1	23-05-2019	NONE	

15

20

25

30

35

40

45

50

55

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82